School of Interdisciplinary Engineering and Sciences (SINES)
National University of Sciences & Technology (NUST)

Analysis of Advanced Biomechanical Systems
Code: CSE 890
Credit hours: 03

Course Brief:

A comprehensive understanding into advance biomechanical research in the areas of movement control, kinetics and kinematics, strength, fatigue, posture, Gait Analysis and locomotion. The course will also introduce the application of biomechanics in sports.

Objectives:

This course is designed to fulfill the following objectives:

1. Develop an ability to understand techniques, skills and tools in engineering practice and be prepared for further education in Mechanical Engineering, Biomechanics/Biomechanical Engineering and/or Biomedical Engineering.
2. To be able to apply the fundamental principles of mechanics to the analysis and simulation of the human movement and gait analysis.
3. To provide the student with significant skillset including:
    a. High end visualization (2D and 3D)
    b. Commercial engineering software e.g. Abaqus CAE or COMSOL Multiphysics/Ansys
    c. GaitSym
    d. Opensim Stanford.
    e. Advanced image processing suites.
    f. Cameragraphy (Motion Capture)
4. Offer a hands-on training in computational modeling of biomechanical systems.
5. To provide an introduction to supercomputers as a data acquisition.
6. Interfacing simulation research to translate into product design and prototype.

Outcomes:

1. Producing mechanical designs of the materials and structures.
2. To train in the research, of computational, experimental and practical skills needed to investigate structure, fluids and solid biomechanical systems.
3. To set up a biomechanics laboratory.
4. Extend outcomes to sports application
5. **Course Code: CSE 890**
6. **Credit Hours: 03**
7. **Course Contents:**
    1. Materials & structures
    2. Mechanical behavior of materials.
    3. Mechanics of materials
        i. Mechanics of biomaterials (bone, cartilage, tendon, ligament and muscle) in response to mechanical stress.
        ii. Application of stress, strain, modulus and creep analysis.
        iii. Mechanical testing procedures in complicated biological geometries.
        iv. Mechanical interaction between organisms.
    4. Gait Analysis

i. Normal Gait Patterns
ii. Abnormal patterns
iii. Rehab mechanism
iv. Motion analysis

5. Stability Analysis and Robot design
6. Orthopedic Biomechanics
7. 2D and 3D analysis of structural biomechanics.
8. Comprehensive review.
9. Brainstorming sessions.

Course format will include readings, lectures, active learning exercises, discussion, group activities in-class quizzes, sessional and final exams.

Course Contents with proposed contact Hours (Weekly plan):

Weekly Plan	Topics Covered
(week 1 – 6)	1. Materials: what they are made of, how they work, what their properties are and how they are used by organisms 2. Structures: what forces they have to resist, what shape they are, what materials they are made of and how they are used by organisms. 3. Creep analysis & Material failure (Failure Mechanics) 4. Gait Analysis
(week 7 – 12)	5. Advance Biomechanical Systems i. Simple Pendulum ii. Double Pendulum iii. Rigid Bodies iv. Ligament Mechanics 6. Langrangian Mechanics & Human Spine 7. Biomechanics of Postures 8. Stability Analysis & Robot design 9. Simulation Solvers
(Week 13 – 17)	10. Orthopedic Biomechanics 11. Sports Biomechanics and Kinematic Analysis 12. Rehab Engineering 13. 2D and 3D analysis of structural biomechanics. 14. Comprehensive review. 15. Brainstorming sessions. 16. Projects

Details of lab work/workshop practice, if applicable: NA Recommended reading, including textbooks, reference books with dates

1. Griffiths, Iwan W. *Principles of biomechanics & motion analysis*. Lippincott Williams & Wilkins, 2006.
2. Zheng, Naiquan, and Steven W. Barrentine. "Biomechanics and motion analysis applied to sports." *Physical Medicine and Rehabilitation Clinics* 11.2 (2000): 309-322.
3. Abrams, Geoffrey D., et al. "Review of tennis serve motion analysis and the biomechanics of three serve types with implications for injury." *Sports Biomechanics* 10.4 (2011): 378-390.

4. Duane V. Knudson, Fundamentals of biomechanics. 2nd ed. Springer, the University of Michigan Press, February 2010. ISBN0387493115, 9780387493114.
5. John D. Currey, Bones: Structure and mechanics, Princeton University Press, June 2002. ISBN: 0691090963 (ISBN13: 9780691090962).
6. Nancy Hamilton, Kathryn Luttgens, Kinesiology: Scientific Basis of Human Motion, McGraw-Hill , June 2007. ISBN: 0072972971 (ISBN13: 9780072972979).
7. Nihat Zkaya, Margareta Nordin, David Goldsheyder, Fundamentals of Biomechanics: Equilibrium, Motion, and Deformation, Springer, May 2012, ISBN: 1461411491 (ISBN13: 9781461411499).
8. Basic Orthopaedic Biomechanics, by Mow and Hayes.
9. Fundamentals of Orthopaedic Biomechanics, by Burstein and Wright.
10. Research Methods in Biomechanics, Author: Robertson, D.G.E., Caldwell, G.E., Hamill, J., Kamen, G., & Whittlesey, S.N. Edition: 2004. Publisher: Champaign, IL: Human Kinetics

Nature of Assessments

Readings, lectures, active learning exercises, discussion, group activities in-class quizzes, sessional and final exams**.**

Comparitive Chart:

Existing	Proposed
1. Materials: what they are made of, how they work, what their properties are and how they are used by organisms 2. Structures: what forces they have to resist, what shape they are, what materials they are made of and how they are used by organisms. 3. Creep analysis & Material failure (Failure Mechanics) 4. Gait Analysis	Retained
5. Advance Biomechanical Systems i. Simple Pendulum ii. Double Pendulum iii. Rigid Bodies iv. Ligament Mechanics	5 (i-iii) Retained (iv) New Content
6. Langrangian Mechanics & Human Spine 7. Biomechanics of Postures 8. Stability Analysis & Robot design 9. Simulation Solvers	Retained
10. Orthopedic Biomechanics 11. Sports Biomechanics and Kinematic Analysis 12. Rehab Engineering	New Content
13. 2D and 3D analysis of structural biomechanics. 14. Comprehensive review. 15. Brainstorming sessions. 16. Projects	Retained

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